Dronning Maud Land 棚氷の過去および将来の急変可能性

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Potential of past and future regime shifts in dynamics of the Dronning Maud Land Ice Shelves

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Ice rises and rumples, grounded features surrounded by ice shelf, are known to significantly impact the motion of ice shelves and upstream glaciers. Ongoing rapid retreat of Pine Island and Thwaites Glaciers was presumably initiated by the loss of an ice rumple near the grounding line, which highlights a realistic risk of rapid changes in ice-shelf speed, thickness, edge position, and eventually regional mass balance trigged by the loss of ice rises and rumples. Delineations and characterizations of past, current, and future ice rises and rumples are thus crucial for predicting ice-sheet evolution, but poorly done primarily because bathymetry data are typically sparse in the vicinity of current ice shelves. Here, we present unique satellite evidence of numerous elevated seabed locations that can potentially accommodate ice rises and rumples embedded in past and possibly future expansions of Dronning Maud Land (DML) Ice Shelves. Satellite imagery acquired between August 2012 and December 2013 show that numerous small icebergs (mostly ~100s meters wide and long) remained at the same positions throughout the period. These stationary icebergs were found almost everywhere within about 50 km from the current ice-shelf edge, but not in front of two ice shelves extending beyond the continental shelf. In most cases, the stationary icebergs were found close to each other and constitute local clusters. Over the observational periods, the icebergs remained unchanged, while adjacent sea ice changed significantly, so sea ice is not a primary factor to constrain these icebergs. Measured bathymetry available at some of these positions show that the seabed ranges 100-300 m below the sea level. These lines of evidence strongly infer that (at least majority of) these stationary icebergs show positions of anomalously elevated seabed, probably banks, which are possible locations of past and future ice rises and rumples. The current amount of ice rises and rumples in the DML ice shelves is much lower than the population of the stationary icebergs (100-800, depending on the periods). Over the last several years, the DML has been a unique region in Antarctica showing mass gain due to increased surface mass balance. Consequently, the DML ice shelves might expand and thicken in the future. We argue that such expanded ice shelves in the future or in the past during the post-LGM deglaciation must have different dynamic regimes than the current ones. Due to inherent dynamic thresholds in ice rises and rumples, these regimes can rapidly shift to more unstable ones, which yield a sudden retreat of the ice sheet and a sudden increase of the sea-level contribution from the DML sector of the Antarctic Ice Sheet.

棚氷の一部が接地している Ice Rise, Ice Rumple は東南極 Dronning Maud Land（DML）沿岸に多数点在しており、この地域の棚氷の安定化に大きく寄与していると考えられている。棚氷規模が変化した時に Ice Rise/Rumple の位置や数がどのように変化するかは、過去のそして将来の棚氷の安定性を考察するうえで不可欠な知識である。しかしながら、この地域の水深測量は極めて不足している。我々はマイクロ波衛星画像を解析することにより、数か月から 1 年に及んで移動しない数百 m 幅の氷山を大量に抽出した。様々な考察を加えることにより、これらの停止氷山の大部分は、盛り上がった海底地形に座礁していると結論した。このような地点（多くの場合は浅堆）では、棚氷が拡大した場合に（一定の条件が整えば）Ice Rise, Ice Rumple が形成される。得られた浅堆と考えられる場所の地域的な分布と数を検討すると、DML 棚氷の多くは Ice Rise/Rumple に強く影響を受けた幾つかの状態間を急速に遷移すると考えられる。DML は南極の中で唯一最近の質量収支が正の地域であり、この傾向が続けば、将来的に棚氷も拡大すると考えられる。したがって本研究で得られた知見は、LGM から現在への地域変動の考察だけではなく、将来変動の考察にも重要となる。